WHITE PAPER

AUTODESK.

BIM WORKFLOW FOR CIVIL PROJECTS

HOW TO ADOPT AND ADAPT

TOPICS

1 CHAMPIONING CHANGE

2 WORKFLOW IMPROVEMENT

3 PROJECT EXECUTION

The move toward a complete Building Information Modeling (BIM) workflow on civil infrastructure projects requires a high degree of commitment. The change is significant, but the rewards far outweigh the initial investment and are compounded as your firm becomes more proficient.

EXECUTIVE SUMMARY

The daunting nature of this change isn't lost on anyone. Every individual must adapt, and whole businesses must retool and reorganize to an extent. Thankfully, this shift to model-based design for civil projects has the benefit of lessons learned from the transformation of BIM within the buildings industry. BIM adoption in buildings was at just 17 percent in 2007, and now building owners expect 75 percent BIM use for projects within the next year (according to a report from McGraw Hill Construction).

The figure of overall return on investment for building projects also is well documented and high, with an average 30 percent return over prior practices. The benefits for improved design, better management of project schedules, reduced errors and better control of costs are the same benefits being realized and expected for civil infrastructure projects.

After deciding to move to BIM, the next consideration is how to do it. Based on conversations with »BIM converts«, the shift requires a measured and thoughtful approach to retool processes and workflows, enhance training, create and alter job descriptions, and, in some cases, reorganize departments and business units. Thankfully, such complex retooling doesn't have to happen immediately to reap rewards, because the change can be tried and tested on pilot projects, and the shift can move from process improvement on projects to an integrated enterprise approach.

The move toward an immersive, intelligent, 3D design experience has been precipitated by nearly 40 years of immersive gaming environments that have become increasingly more realistic. The expectation and skill sets of individuals to manipulate and model in 3D is increasing, as one of the more-popular gaming platforms is Minecraft, which allows players to create procedurally generated 3D worlds. This growing skill level is coming at the right time to bolster efforts for this 3D model-based design shift, aiding those with decades of 2D design experience.

> When it all kicked off, it scared the life out of me to be honest. Because I come from the background of the technician doing the drawing and modeling. I looked at BIM and thought that I've got to draw and model, and handle process management. I felt that I couldn't do both, but I realized soon on that we need to have everybody fully engaged to make it work.
>
> *Chris Bargent, IEng MIED, Associate, Transport/Bridges, Ramboll UK Ltd.*

Process and workflow changes are enabled by technology progression that centers on the project, with integration and interoperability that breaks down silos with software. This allows models to progress through different design and engineering phases across departments and with input from external stakeholders. The adoption of cloud computing is a further enabler with simpler installation and access as well as a more powerful toolset that places less burden on technical understanding and hardware investment, getting users up and running far more easily and quickly.

Those who made the leap are finding rewards by starting with large projects that bring in broader teams. High-profile »all in« on BIM projects fosters a learning environment with shared knowledge and process improvements through shared objectives, standards and specifications.

Although returns on BIM for civil projects are being found immediately, the road map for continued rewards is the most compelling driver for adoption. How companies and government agencies are approaching the implementation is explored in this white paper.

1 CHAMPIONING CHANGE

Whether called Civil Integrated Management (CIM), Virtual Design and Construction (VDC), or the more-common Building Information Modeling (BIM), civil projects' move to BIM requires leadership on many levels. Top management must commit and foster the vision while enlisting managers to organize and advance the change, while individuals must adopt a new mindset and skillset.

FOSTERING BUY-IN

Addressing challenges that couldn't be resolved in 2D design often is the impetus for BIM deployment. Trying to uncover potential problems while standing around a full plan view with different design sheets from various disciplines for a complex infrastructure project has historically led to frustration.

The underground complexity of placing pipes and cables is an excellent example of complexity that confounds 2D representation. This problem requires a 3D understanding of what exists as well as developing a 3D plan for what needs to happen in construction. Rallying around a model helps everyone understand the implications of a full-scale shift to 3D.

To gain the buy-in necessary for a successful BIM implementation, benefits to individuals on the project team must be evident. Each person needs to see how easy it is to make a change for some of the more-involved drawings and designs.

With model-based tools, a significant change is more easily handled because the relationships among objects are maintained in the model rather than locked into individual design sheets that need updating. What may have taken 20 hours to update and cross-reference can take just a few hours to fix in BIM. Such a reduction in change pain is motivation enough for most to do whatever it takes to accelerate implementation. The growing number of case studies illustrating the success others have had on similar projects provides further proof that implementing BIM on civil projects isn't impossible.

> Since a broad majority of the workflows have changed quite a bit, it's a little disruptive. Most people embrace change, and there's always continuing education at our DOT. If you don't train, you don't get your continuing education units to stay current on your professional license.
>
> *Lance Parve, Senior Project Engineer/Hydrogeologist, Wisconsin DOT*

TRAINING AND CHANGING

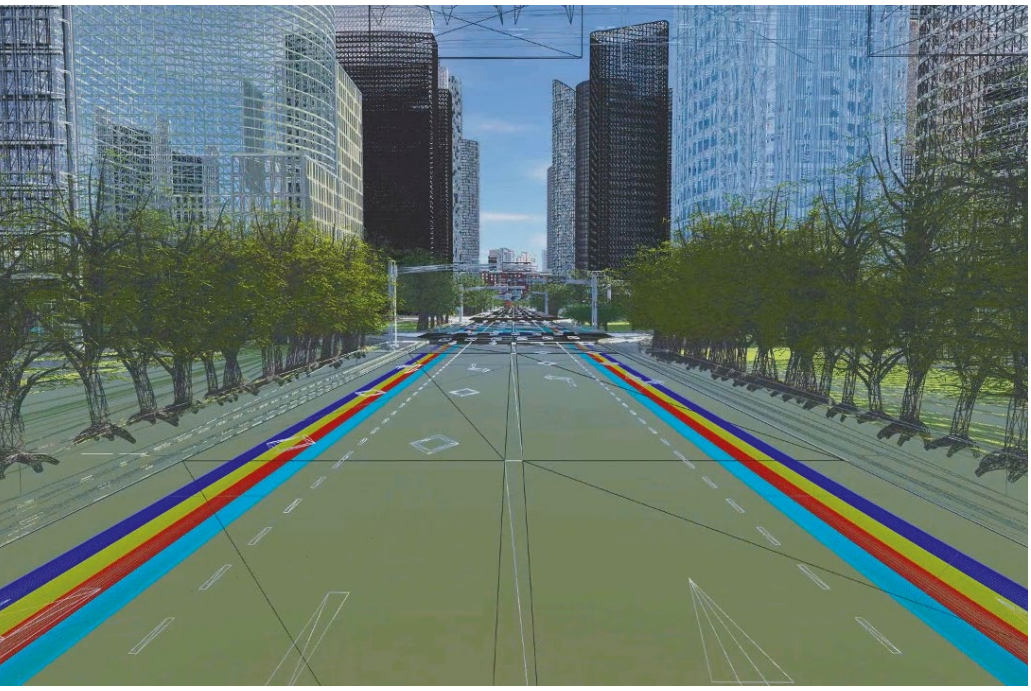
The role of draftsperson or technician is most likely to change, because engineers are required to interface with the model, rather than just provide sketches or calculations. Instead of draftspeople drawing what they're told, engineers must engage and build models that conform to their sketches and calculations, adding their intelligence to the shared model.

This change alone requires new alignments for displaced draftspeople and new software skills for engineers. Some draftspeople align with software training to teach the skills, and others may shift into more of a process-management role. Deciding who leads the charge and how training gets propagated throughout a firm differs across organizations. Most look to a regular course schedule and a growing repository for on-demand learning, coupled with experts who can assist should problems arise during project work.

The approach often has been to train »just-in-time« and »train the trainer«. Firms look to get a specialist on the team when the proper project arises. They then look to get the necessary software and train a person to be the expert, who then trains others as they come onboard.

Projects that use BIM processes also provide a means for cross-generational training, with younger, less-experienced staff working alongside more senior people who don't have the same familiarity with parametric modeling tools. The shift offers the impetus for a cultural boost within the organization, with opportunities for mentoring and instilling the firm's values and expertise within the next generation, while taking advantage of the newer skill set.

> The bulk of those leading the way are more technical or acclimated because of their schooling. A person who has done gaming all their life, it just comes natural, whereas someone used to 2D tends to default to that world. It's our broad mission and strategy to incorporate everybody in the 3D arena, because all our workflows have changed.
>
> *Lance Parve, Senior Project Engineer/Hydrogeologist, Wisconsin DOT*



This detailed model from the Municipal Road Engineering of the Sichuan Transport Surveying and Design Institute (SCODI), China models both above-ground and below-ground infrastructure for greater situational awareness.

> BIM will force people to collaborate much earlier, and there will be very clear shared responsibility. Because we'll have to work to well-defined levels of detail, and people will know and understand what a model can be used for, I think it takes all the ambiguity we currently have and washes it away, giving us a nice, clear picture of what's expected.
>
> *Chris Bargent, IEng MIED, Associate, Transport/Bridges, Ramboll UK Ltd.*

CATCHING UP TO REQUIREMENTS

Bringing multiple disciplines together is one of the biggest benefits of BIM, but the evolution can be slow moving to reach all those who benefit. In the United Kingdom, the mandate for Level 2 BIM for government projects is a unique means of forcing buy-in as well as an aggressive goal to have that in place by 2016. This push required many firms to devote a lot of resources to understand the implications and enact new approaches, as Level 2 goes beyond modeling to outcomes related to project scheduling and tightened controls on budgets for better project management.

With the mandate, the road map is secured, but the many stakeholders still are struggling with what they want out of the model. This is particularly true for those who receive the model after construction is complete, as they can understand the benefits but may not have the tools to use and take advantage of the intelligence.

> The people are the glue. They're at the beginning, the middle and the end. If you don't get the recipe right around engaging the different stakeholders throughout the whole lifecycle, then you don't get the value of the outcome you desire.
>
> *Donna Huey, Senior Vice President, Director of Strategic Ventures, Atkins*

The mandate is a heavy-handed approach to force change industrywide, but it's resulting in an acceleration and, indeed, a global expansion. Several other countries have followed, and increasingly more owners are demanding BIM for new projects. Given this rising tide, wider use will spur continued adoption, and uses for the model will grow.

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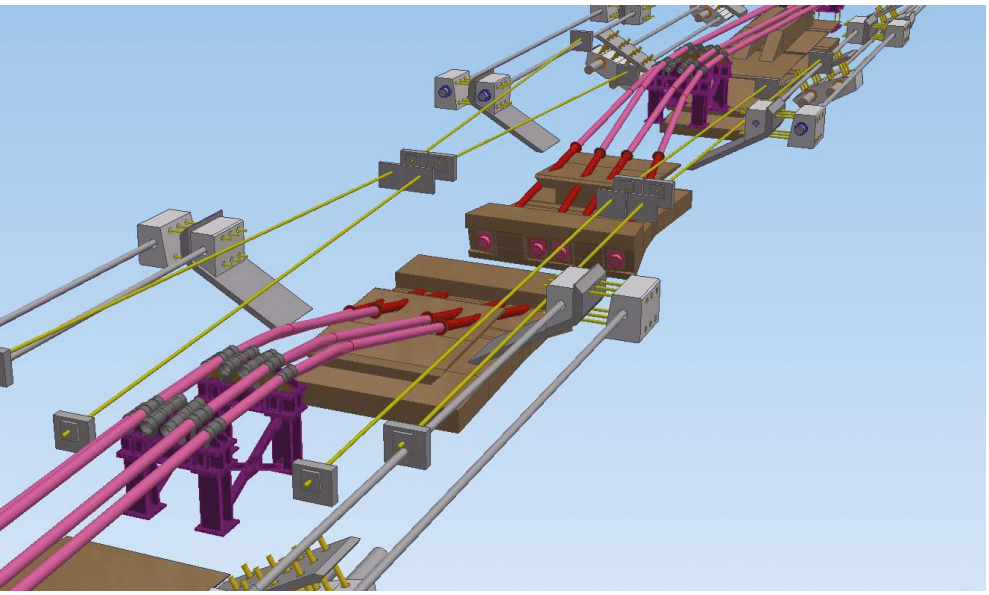
> We have to consider that this is an adaptive change management. When we think about the way we have done things, we have that muscle memory. We need to look at the people (what they hold true and what they're used to doing), the dynamics of process, and continuing to iterate the importance of change. People naturally want to gravitate back to the way they've always done things.
>
> *Donna Huey, Senior Vice President, Director of Strategic Ventures, Atkins*

BREAKING FROM THE PAST

As the transition is tackled, there's a need to institutionalize change and continue to communicate the end benefits. A well-defined set of goals and a shared progression will go a long way to align energies.

With such considerable change, there will be pain and pushback. It's not an easy task to alter old workflows and deal with differing attitudes and skills. Chaos and conflict are unavoidable at some scale. Maintaining order amidst the change is imperative, and it's done through clear communication, fostering collaboration and conflict resolution rather than conflict avoidance.

In light of the challenge, there's a need for persistence. Some find an approach that focuses on progression to be beneficial, where the practice of the past is eased into the new through incremental change management. There will be many things you'll need to stop doing, and many you'll want to preserve.



The Hammersmith Strengthening project for Transport for London added post tensioning strengthening and bearing replacement of an existing 622 meter long 16-span segmental pre-cast concrete post tensioned bridge. The model details the new system that made the structure independent from the existing post-tensioning system. This was a pilot project by Ramboll, UK for implementing BIM level 2 standards.

2 WORKFLOW IMPROVEMENT

The new road and bridge crossing the Sulafjord replaces an existing ferry connection with two tunnels of approximately .5 km each and a two span suspension bridge with a total span of 4200 meters.

As gains on projects have been achieved and verified, BIM has been moving beyond a project approach toward an enterprise approach. Early adopters now are institutionalizing BIM as standard practice, and along with such elevation, they're looking to adapt their processes.

The need to change offers the opportunity for process improvement. The wholesale need for adaptation allows all avenues to be explored. Such a pause and assessment stage helps identify traditional bottlenecks and then circumvent them. Engaging all stakeholders in this assessment fosters buy-in and can help identify opportunities for easing project workflow from those who have most directly experienced pain in the past.

> It's a complete change to how the industry works. With a design and build, commonly there is a partial design in place, and you hit the ground running with the first deadlines and delivery. Now, that's all got to stop, because there's a lot of planning needed to successfully deliver a BIM project. You sit down with the client and all the parties, and you plan how you're going to deliver the project before you begin any design work.
>
> *Chris Bargent, IEng MIED, Associate, Transport/Bridges, Ramboll UK Ltd.*

STANDARDS AND WORKFLOWS

Many organizations start with a »BIM Manual« that includes information standards and outlines improved electronic data sharing among disciplines. There can be project-oriented as well as institutional manuals that set up guidelines for doing business. The manuals are used by those performing engineering design services with protocols and standards, best practices and examples for consistent models. The standards also are aligned to contracts, which help ensure compliance on projects via performance measures.

Such standards for project work are combined with process and project workflows that also need examination. In many cases, there's an opportunity to introduce automation, where today's software can analyze a lot of data or perform simulations based on design performance to improve the model and final designs.

The need to share data across time zones and devices comes into play within the definition of these workflows, emphasizing the need for shareable models as well as portable and easy-to-access platforms and tools. The ability to access models on phones and tablets is particularly compelling for sharing models with field crews and communicating with owners and other stakeholders. The model's portability provides improved collaboration at the outset, which is the leading requirement of a BIM approach where planning has become much more important.

> Right now, we're testing out combining four different companies in a railway project – local architect, Multiconsult, cultural conservationists – all working in completely different software. We'll have 100 people when it all gets up and running. Every afternoon, each individual will need to sync their model with all other models produced that day. All the people will be able to work from their local office or home office thanks to a cloud solution.
>
> *Marius Sekse, Landscape Architect and Head of BIM for Infrastructure, COWI*

COORDINATED DATA MANAGEMENT

Many firms are using pilot research/development projects to inform process and software choices. The pilot projects help collaborate with a shared goal and understanding that everyone is in a learning mode. This environment allows stakeholders to explore and test and try a particular approach as well as gauge how the approach impacts the prior practice still in place.

The move to BIM with large project teams on complicated and multi-year projects has helped foster the shift. Coordinated data management at the larger scale of these projects is facilitated through shared databases and data-sharing protocols to keep everyone up to speed.

Putting the project at the center and establishing a central database creates a common point of truth, where if something gets changed, the changes are propagated to everyone's model. Anyone across the globe can contribute, and many large international firms take advantage of this capability by spreading the work around the globe and thus around the clock.

SHARED EXPERIENCE

BIM really shines in the collaborative process that involves a wide range of stakeholders sharing a central model. Combining different disciplines with different contributions within the same model provides greater clarity on responsibilities as well as scheduling and project sequence. Establishing standards relative to what type and level of information must be shared for the different model elements is an important aspect of the process.

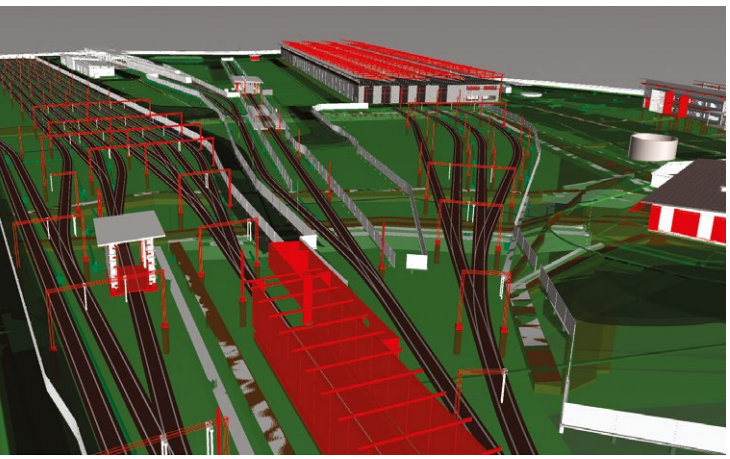
Such sharing provides the means for clash detection, as all disciplines can clearly see the work of others, down to minute details for complex elements. Such transparency of design detail and clearly assigned responsibility allows for greater understanding of the whole as well as a model that's ripe and ready to aid ongoing maintenance.

> Multidisciplinary collaboration is what it's about. It's in everybody's best interest to be on the same page. It's more of a spirit of collaboration now. It's such a leap that if you're not sharing, you're really not advancing.
>
> *Lance Parve, Senior Project Engineer/Hydrogeologist, Wisconsin DOT*

3 PROJECT EXECUTION

> Having the client accessing your models and doing markups and commenting is a good way of working as long as it's an internal workflow. As soon as we start talking about external, with public feedback, we are hesitant, because we may show a road or railway going through a house, and it could impact the project if we overshare.
>
> *Marius Sekse, Landscape Architect and Head of BIM for Infrastructure, COWI*

With the model-based collaborative approach, there are many efficiencies gained in construction execution, which is why it's important to include model standards and level-of-detail requirements during BIM implementation. Many firms have reduced or eliminated clashes – and early on when it costs much less to correct. A more-detailed model also helps reduce the number of requests for information (RFIs), because of the model's additional level of detail. And due to the virtual construction that takes place in the model, there also are fewer change orders from the site.



The North West Rail Link project inspired SMEC to accelerate the pace of BIM adoption. The team quickly began to view BIM as a process that connects all aspects of a project – not a technology or software tool.

INFORMATION CAPTURE AND EXCHANGE

At the center of BIM workflows are the 3D technologies and modeling tools. This starts with the need to collect »reality« via integrated 3D survey tools (primarily LiDAR scanners coupled with cameras that automatically color the 3D representation) to inform the design with the capture of full 3D comprehensive models at engineering-grade accuracy.

Such accurate and dense measurements in the point-cloud model provide the direction for all the disciplines to build upon, with great insight to all existing elements. With this established as standard practice, everyone can work with and integrate the representation from conceptual stage through completion.

The workflows of conceptual design are informed by this model, and standard processes should specify how to use the model to discover and address problem areas well before getting to detailed design work. Modeling from the beginning helps extend project dollars to work smarter, faster and cheaper. The reality capture improves understanding and requires fewer repeat measurements, and those that are repeated can be a complete collection to gauge progress.

Some technologies have come seamlessly from the vertical building industry into the horizontal infrastructure industry. They have been fine-tuned and are starting to take hold, advancing to many owners of civil infrastructure projects.

> Collaboration and openness are key to BIM, as there's none of the 'blame game.' It's all about working together and designing standards and protocols in the beginning, so you can work together and trust what you're receiving, and people can trust what you're giving, because you're working to a known level of accuracy. They know what you've been tasked to deliver, with no black areas. It's a brave new world, where we all have to be very trusting.
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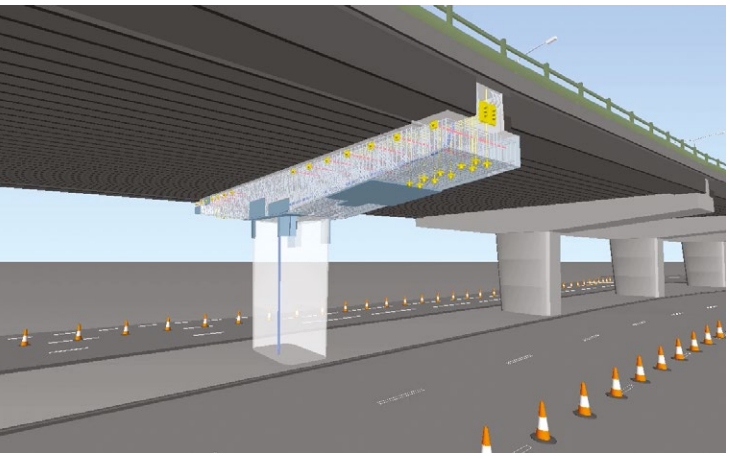
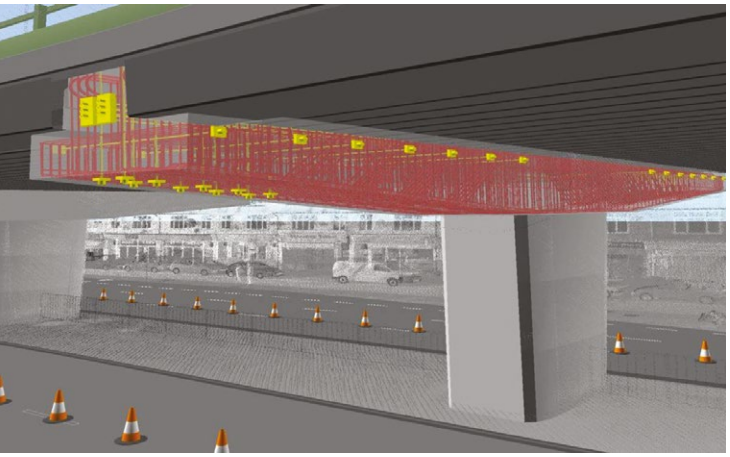
> *Chris Bargent, IEng MIED, Associate, Transport/Bridges, Ramboll UK Ltd.*





Virtual construction is one of the key benefits of BIM to the Atkins team that worked on the M4 Motorway Elevated Section as part of Connect Plus – a DBFO consortium. Atkins was able to design and test virtually before construction so that they could minimize clashes with existing reinforcement of the bridge. This helped to facilitate better data management and allowed them to perform virtual rehearsals to maximize efficiency of construction.

SHARED ADVANTAGE

Openness with project partners is key to BIM advancement and important to consider during implementation. Being open as well as demonstrating capabilities and understanding with joint venture partners can set the tone for collaborative project work.

Firms that have successfully implemented BIM stress the importance of being open with processes and workflows to foster a team approach that empowers others to suggest changes and help troubleshoot problem areas. You may find someone who has an idea that will create a spark to try things in a different and improved way.

Better-coordinated workflows and shared insights, without animosity and with less competition, improves the end product.

> It's getting to the point now with certain contractors, that it's very comfortable—the contractor is pushing BIM, and they know we're pushing BIM, so our wishlist on the last project is a starting point for new projects. We can add more complexity each time. With that progression, you start to leap ahead of other people, because you've already done it before, and the amalgamation of minds come together, and you start to complement one another.
>
> *Chris Bargent, IEng MIED, Associate, Transport/Bridges, Ramboll UK Ltd.*

PROJECT PROGRESSION

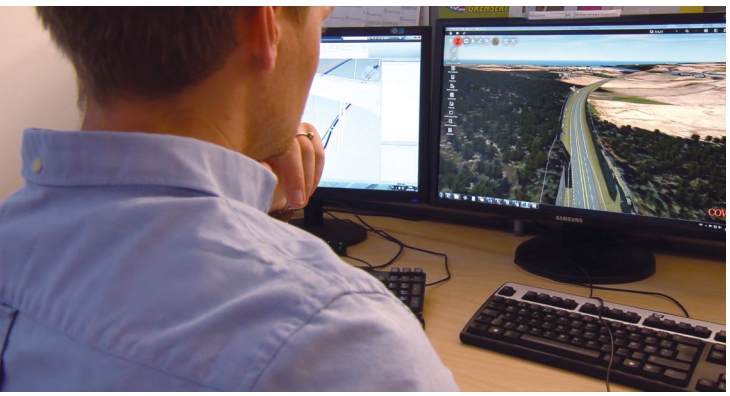
The road to the nirvana of a shared project model can be short … or it can be long. To date, the vision of BIM is the clearest element, with varying degrees of success. Many projects, including the complicated ones mandating BIM, currently are somewhat a retrofit, with certain parts designed in the old-fashioned way and then integrated back into the detailed, shared model after design work is done.

Getting to the full 3D modeling workflow will take time, using each project as an interim step toward the ultimate goal. Along the way, you may find the perfect partner where you enable one another's workflows and are working in tandem to improve the outcome and foster the most-efficient workflow.

NEVER EASIER THAN NOW

Due to more-flexible technology, it's never been easier than now to enact wide-scale process change. The building and infrastructure industries are far behind the improved efficiencies the manufacturing sector has realized due to model-based design. And just as the horizontal infrastructure of civil projects are benefitting from the advancements of vertical building projects in regard to BIM, both applications are reaping the rewards coming from manufacturing: the ability to capture quickly in 3D with a high degree of precision; model and analyze with the »bottom line« in mind; simulate with an eye on performance; and deliver a lean, »just-in-time« assembly process that speeds up project timelines while reducing manufacturing costs.

We're in an era of greater connectivity among models and designers, engineers, contractors and operators. The tools are in place to foster this move, and they will continue to advance with a focus on ease of use, automation and the improved ability to achieve desired design outcomes.



COWI Norway had experience with 3-D projects and design, but no BIM process from conceptual to preliminary designs. They considered this a missing a tool for presenting large-terrain projects where they needed to present GIS and CAD in a common environment to aid in decision-making. With the implementation of BIM into earlier stages of preliminary design and analysis of the E16 highway project, they were able to shift thinking about how BIM should be implemented on projects moving forward.

SUMMARY

SUMMARY

How firms and government agencies approach BIM implementation is progressing in chaotic yet measured ways. There's a need for wholesale process and workflow improvement as well as a need to learn to use whatever tool delivers projects in the most-efficient and effective way.

A key element of such BIM progression is the need to integrate tools and processes within organizations as well as with all stakeholders across the entire project lifecycle. Collaborative workflows that break down barriers are central to improved processes and better-quality project outcomes.

The need to innovate is a balancing act, with a focus on cost savings and improved outcomes. The approaches are carefully vetted around saving time and money, and BIM for civil projects has achieved both outcomes when put to this test. BIM is a winner, and it's being widely adopted because it helps deliver projects on schedule and under budget.

As we head into a phase of widespread BIM for civil infrastructure adoption, it's important to allow room for continued fine tuning without rigid frameworks for exactly how BIM for civil infrastructure projects should be implemented.

The transition toward BIM needs to be a fluid process, where responsibility is shared among the building process, the information amassed and shared, overall model management, and its realization. It's not about the model or building process, but more about the fluidity of information. Keeping an open mind, with an eye on progress, is an essential element to foster the greatest rewards from this change.

RESOURCES

This whitepaper is an adaptation of a document produced for Autodesk, Inc., by V1 Media, 8421 E. Oregon Place, Denver CO 80231 – info@informedinfrastructure.com

National (UK) BIM Report 2015, National Building Specification (NBS), part of the UK Government's Construction Strategy BIM Working Group

SmartMarket BIM Research and McGraw Hill Construction

openINFRA Initiative, with the BuildingSMART alliance